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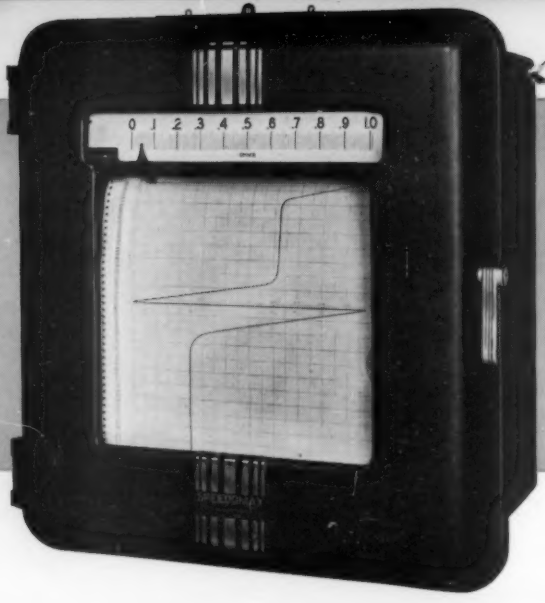

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Operations Diagnosis in Research Planning

THERE are two basic reasons why the officers of a company set aside certain portions of the company's income to be spent on research. One is that they believe the company has current problems that can be solved through scientific investigation. The other is the knowledge that research may uncover new opportunities for bettering the company's competitive position.

The measure, then, of the effectiveness of a corporate research program is how well it solves corporate problems, and how well it uncovers industrial opportunities. Research that seems sound, worthy, and well directed while in progress but that does not lead to the fulfillment of one of these goals does not accomplish its function. It may produce scientifically interesting information, stimulate creative thinking, and result in useful by-products. But, unless it pays off in terms of corporate progress, it has not been a good investment from a business standpoint.

Obviously, if company research is to pay off, it must be well planned. In large companies today, business operations are so complex that it is no longer safe for management to make decisions based on individual judgment, even though this judgment results from broad and intensive experience in the company's affairs. For this reason, management in many industries is turning to techniques of scientific analysis to arrive at information necessary for making decisions.

Operations research is one technique for analyzing problems and determining the best approaches to technical research. Industry borrowed this tool from the military, when it was developed during the war to analyze the factors involved in a military operation. It embraces the relating of complex variables affecting an operation in a mathematical manner to show cause and effect. It has proved remarkably effective both in military and in industrial applications.

Engineering economics, another tool used by management to analyze company problems, is essentially a science of prediction of technical economic opportunities and risks. It provides a quantitative analysis of markets, sources of raw materials, opportunities for diversification, industrial logistics and plant location, the competitive effects of technology, and research planning. Operations research and engineering economics overlap to some extent.

At Battelle, in diagnosing the factors that enter into the planning of research, we combine operations research and engineering economics, and call the analytical procedures by a new term—"operations diagnosis." If a problem for industry, it is "industrial operations diagnosis;" if for the military, "military operations diagnosis."

This concept has an obvious parallel in medicine. A business organization may be compared to a biological organism. Both are organizations of intricately related parts, each with delicate function. In medicine, we diagnose what is wrong with the organism and then prescribe a remedy. With modern scientific tools, we can likewise diagnose what is wrong in an industrial operation and prescribe a remedy. The remedy may be either a planned program of technical research or carefully considered counsel for management action. In such an approach the industry is regarded as a unit, and the function of any part is considered only in relation to the whole. By diagnosing scientifically the causes of symptoms, remedial actions need not be based on hunches, pet ideas, or makeshift expedients, but on properly evaluated methods for removing the causes. Futile research on superficial indications is eliminated, and an efficient attack is formulated on the basic source of trouble. Problems of semantics in communication among members of management are reduced when the diagnostic approach is assumed.

The idea embodied in "operations diagnosis" tends to make research more efficient, by showing clear roads to profitable investigation. Anything that helps make research a more exact tool for industrial progress also stimulates science and technology generally.

CLYDE WILLIAMS

Battelle Memorial Institute
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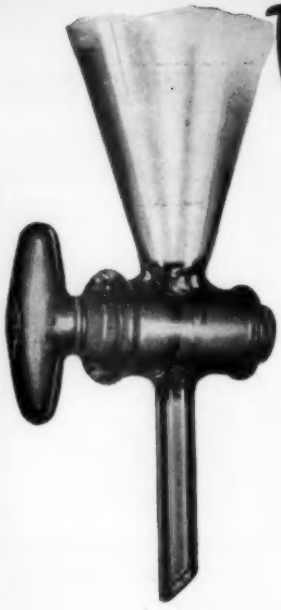

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White Mountain High Altitude Research Station

S. F. Cook and Nello Pace

Department of Physiology, School of Medicine, University of California, Berkeley

THE WHITE MOUNTAIN HIGH ALTITUDE RESEARCH STATION has recently been made available to investigators in both the physical and the biological sciences, through the action of three contributing agencies: the Office of Naval Research, the National Science Foundation, and the Rockefeller Foundation for Medical Research. Each agency has announced that it will underwrite one third of the maintenance costs of the station for a period of three years. The funds will be administered by the president and regents of the University of California through a committee of faculty members, and the authors will be in immediate charge of operations.

The White Mountain Station had its inception in 1948, when the U. S. Naval Ordnance Test Station at Inyokern, California, built a road and erected a laboratory in the southern portion of the White Mountain Range at an elevation of 10,600 feet. The buildings were used throughout 1948 and 1949 for classified work by the Ordnance Test Station and for nonclassified research by several university physicists.

In 1950 the entire installation was transferred to the cognizance of ONR, and operation of the station was delegated to the University of California by contract. Up to this time it had been used exclusively for physical research. The principal investigators under the contract believed that the location is suitable for the conduct of investigations pertaining to the effect of high altitude upon man and animals. Nevertheless, the existing facility was situated at somewhat too low an elevation for the investigation of many biological problems. Accordingly, in the summer of 1951 a new building was erected at an altitude of 12,500 feet. The present station thus consists of two substations—one at 10,600 and the other at 12,500 feet. Very accessible, also, is the summit of White Mountain itself, at an elevation of 14,250 feet.

The White Mountain Range, with a north-south axis of nearly 100 miles, forms a part of the Inyo National Forest and lies just to the east of the northern extremity of the Owens Valley in California. It is, in fact, the most westerly of the Great Basin ranges between the 37th and the 38th parallels. The climate on the whole is arid, with an average annual precipitation of approximately 13 inches of water (Fig. 1). Most of the precipitation occurs as snow in the winter, when the cyclonic storms from the Pacific Ocean cross the Sierra Nevada to the west and reach the White Mountain Range. Owing, however, to the loss of moisture in the Sierra, these storms are less severe at White Mountain. During the exceptionally severe winter of 1951–52 the total snowfall at the White Mountain Station was only 157 inches, or roughly one fifth as much as occurred in the nearby Sierra Nevada.

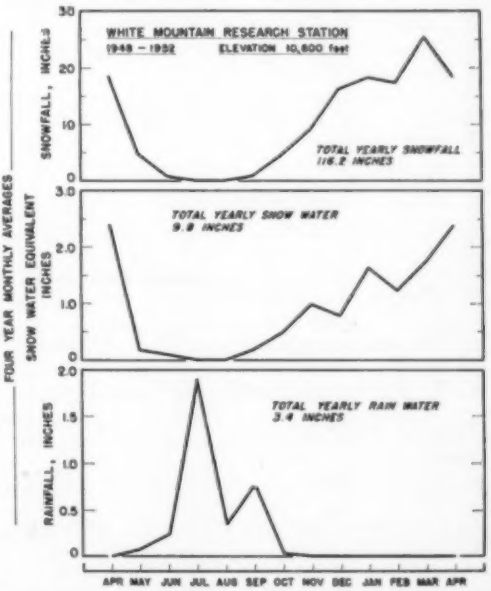
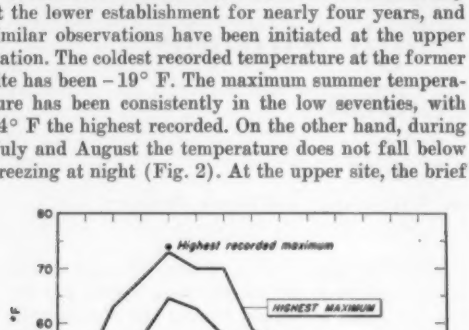


FIG. 1. Monthly precipitation at an elevation of 10,600 feet in the White Mountains, as a mean of the four-year period from October 1948 to July 1952.

A full year's data on relative atmospheric purity at the station, obtained by Fritz Zwicky in 1949, were compared with similar data from Sacramento Peak in New Mexico and from Climax, Colorado, by Walter O. Roberts, superintendent of the High Altitude Observatory of Harvard University and the University of Colorado (*1*). He stated in his report that White Mountain is the superior site for solar coronal research, although he recommended Climax because of the relative inaccessibility of White Mountain at that time.

Weather observations have been taken continuously at the lower establishment for nearly four years, and similar observations have been initiated at the upper station. The coldest recorded temperature at the former site has been −19° F. The maximum summer temperature has been consistently in the low seventies, with 74° F the highest recorded. On the other hand, during July and August the temperature does not fall below freezing at night (Fig. 2). At the upper site, the brief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1948 – 1952 ELEVATION 10,600 feet
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FIG. 2. Air temperatures at an elevation of 10,600 feet in the White Mountains, based on the 24-hour maximum and minimum temperature recordings. The curves represent a four-year mean of the highest maximum and lowest minimum temperatures in each month, as well as the average maximum and minimum temperatures for each month. Also shown are the highest single maximum temperature and lowest single minimum temperature recorded during the four-year period from October 1948 to July 1952.

period of observation available to us indicates that the temperature averages about 10 degrees below that of the lower site.

From Fig. 3 it may be seen that the relative humidity fluctuates from about 40 per cent in the summer to about 60 per cent in the winter. Wind velocities are relatively low in the summer, but during the winter they have reached recorded values of 50 knots average for one hour at the lower site. At the 12,500-foot level higher velocities are encountered—up to at least a one-hour average value of 70 knots. The barometric pressure exhibits a regular and rather large cyclic variation over the year. The monthly average falls from a value of about 516 mm Hg in the summer to approximately 505 mm Hg in the winter, which represents a change of about 500 feet in equivalent altitude. For the completeness of our meteorological data we are indebted to the continued interest and material assistance of Charles L. D'Ooge and H. W. Hunter, of the U. S. Naval Ordnance Test Station, Inyokern.

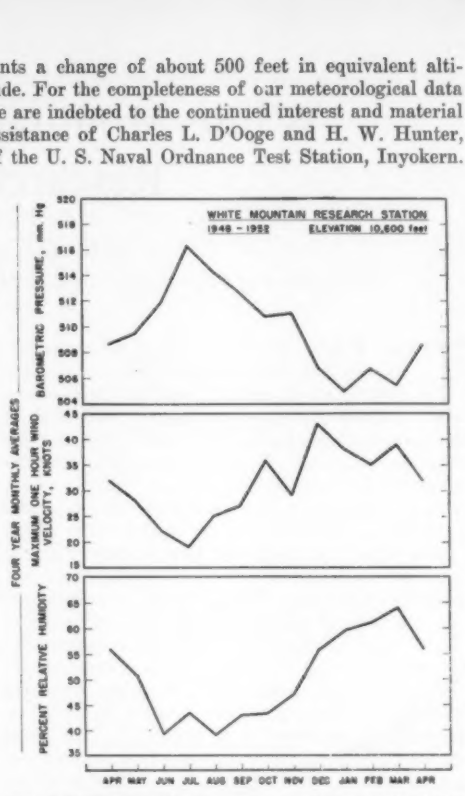
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FIG. 3. Mean barometric pressure, maximum wind velocity, and relative humidity at an elevation of 10,600 feet in the White Mountains for the four-year period from October 1948 to July 1952. The barometric pressure and relative humidity data are the monthly averages of daily readings at 0800. The wind velocity data represent the four-year average of the highest velocity during each month.

Approach to White Mountain is through Bishop and Big Pine in the Owens Valley, both situated on U. S. Highway 395 (Fig. 4). From Big Pine a paved road runs eastward 13 miles to the top of Westgaard Pass at the summit of the southern extension of the White Mountain Range, an elevation of approximately 7000 feet. From this point a dirt road goes north for 20 miles along the axis of the range to the original laboratory constructed by the Ordnance Test Station. This facility consists of two structures. The first, located on the headwaters of Crooked Creek, is a wooden frame building that serves as living quarters and operations base for water, power, and communications. The cooking, sleeping, and sanitary facilities are adequate to accommodate from 10 to 14 persons, and a perennial spring furnishes an excellent and copious water supply. A telephone line connects with the central office at Bishop. Power is provided by two diesel generators capable of producing 25 kva of 60-cycle, 3-phase alternating current at 220 volts, and all buildings are wired with standard 110-volt, 60-cycle, a-c outlets. The second building is a 20′ × 40′ Quonset located on the brow

of a hill, approximately 400 feet above the living quarters at Lat. 37° 30.0′ N and Long. 118° 10.0′ W. This building is provided with power and is suitable for many types of laboratory work.

From the Crooked Creek Station a dirt road continues 9 miles north and 2000 feet higher to the base of a peak just 4 miles south of White Mountain itself, which recently has been officially named Mount Barcroft, in honor of the late Sir Joseph Barcroft, whose work in high-altitude physiology is universally recognized. At this point, Lat. 37° 35.1′ N and Long. 118° 14.1′ W, stands the 40′ × 100′ Quonset that was erected last year. Its two floors provide living and working facilities. On the lower floor are the kitchen, washrooms, dining room, office, and living room, together with two large laboratories. The sleeping quarters on the upper floor accommodate 24 persons. Water is secured from a well beside the building, and power comes from diesel generators similar to those at the Crooked Creek Station. One end of the hut is devoted to a 30′ × 40′ heated garage.

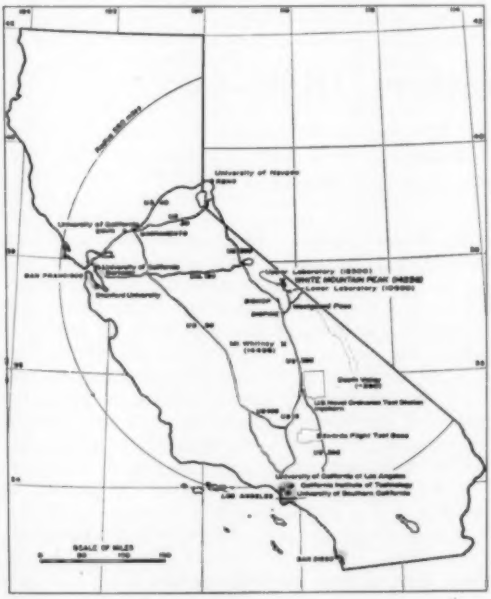

FIG. 4. General location of the White Mountain Research Station.

Although the dirt road leading from Westgaard Pass to the Crooked Creek and the Mount Barcroft laboratories can be traversed by trucks and other heavy vehicles, the grades are steep, and visitors should discuss their plans with the station operators prior to bringing in their automotive equipment. Plans are now under way to relocate and improve the road.

One of the long-term advantages of the White Mountain area is the low average annual precipitation. This means that year-round operations can be anticipated with a reasonable degree of certainty. The Crooked Creek Station has been kept open during four winters, even that of 1951–52. The Mount Barcroft Station was finished too late in the season of 1951 to warrant attempting to keep it in full operation through the winter, but it is expected that hereafter it will be kept open for scientific work. Communications during the winter are maintained either by keeping the road open to automobile or jeep traffic, or by utilizing snow vehicles such as weasels and sno-cats. The latter procedure is made feasible not only by the relatively light average snowfall, but also by the open, treeless terrain and the gentle slopes that prevail at higher altitudes.

Although until recently the White Mountain Station has not been available to investigators at large, it has already provided the facilities for the study of several important problems. Thus, as early as 1949, studies were made of cosmic radiation by two independent groups, one headed by Carl D. Anderson, of the California Institute of Technology, and the other by R. B. Brode and W. B. Fretter, of the University of California, Berkeley. In 1950 the site was used by L. P. Delsasso and R. W. Leonard, of the University of California, Los Angeles, for extensive experiments on the velocity of sound. At present further cosmic ray investigations are being conducted at the Crooked Creek Station by E. D. Palmatier, of the University of North Carolina, and W. Brown, of Duke University. Studies of the electrical conductivity and potential gradients of the atmosphere are also being made under the direction of R. E. Holzer, of the University of California, Los Angeles.

In the biological sciences, experiments were carried on during the summer of 1950 with reference to the gas exchange of laboratory mice when exposed to a moderate altitude. At that time, furthermore, the laboratory established colonies of mice (A-strain and Swiss) and rats (Long Evans) and has continued to propagate them since. The objective is to develop strains that over many generations will have become thoroughly adapted to a high altitude. These high-altitude animals will then be available for study by any biologists who may be interested. Correlated studies are also being undertaken with respect to reproductivity and the sex cycle in the native wild rodents. Investigation of the role of myoglobin in the process of acclimatization to hypoxia is being carried out on some of the laboratory animals at the present time.

Another significant problem being investigated at the Mount Barcroft Station is that of long-term bulk food storage. The keeping qualities of rations stored in a cold, low-oxygen environment are being compared with the preservation of those stored in the warmer, high-oxygen environment near sea level.

The foregoing investigations are mentioned as examples of the type of problem for the study of which the White Mountain Station is suitable. It should be noted, moreover, that the entire area offers unique opportunities for field work in ecology and related branches of biology. Within an hour's drive from the

Crooked Creek Laboratory one can reach elevations of 4000–13,000 feet and temperatures ranging from freezing to well over 100° F.

It is the intention of the supporting agencies, as well as of the University of California, that the facilities of the White Mountain High Altitude Station be made available to all interested scientists equally, whatever their university or governmental affiliation. Indoor laboratory space is limited at present to approximately 1000 square feet at each of the two substations, although it is possible that more space could be secured in the future if warranted by demand. Aside from power, water, and heat, the installation has at its disposal very little in the way of laboratory facilities, although as a matter of policy it is intended to build up as rapidly as possible a backlog of standard pieces of apparatus, such as balances, ovens, etc., which can be used by visiting investigators. In the meantime, anyone intending to work at White Mountain should bring his equipment with him.

Since the basic maintenance is being provided by the three agencies initially referred to, and since there is no other source of operating income, it seems legitimate to charge each active investigator approximately $5.00 per day, plus power and special services at cost.

The White Mountain area is isolated and remote from any large centers of population. The living quarters at both Crooked Creek and Mount Barcroft are comfortable and are available without extra charge to unattached men living at the station. Current funds, however, are not sufficient for the construction of the new buildings that will be necessary for the housing of families. Visitors and investigators, therefore, who wish to bring their families should plan to establish them at a hotel or auto-court in the Owens Valley or provide a trailer that can be brought to the station. Details will be furnished by the authors upon request.

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Eugene Curtis Auchter: 1889–1952

Frederick D. Richey

Agricultural Experiment Station, Knoxville, Tennessee

THE DEATH OF EUGENE CURTIS AUCHTER on July 8, 1952, in Honolulu, brought to a close a long and productive career as an inspiring teacher, an able researcher, and a capable administrator in a broad field of plant science. At the time of his death, he was consulting scientist to the Pineapple Research Institute of Hawaii, of which he had been president and director from 1945 until May 31 of this year, when continuing illness forced his retirement.

Dr. Auchter was born in Elmgrove, New York, September 14, 1889. He spent his boyhood working there on the family farms, which produced a large variety of fruits, vegetables, and flowers for the market. In this way he gained an extensive and intimate knowledge of practical horticulture in all its many branches even before he went to Cornell University, where he received a B.S.A. degree in 1912, an M.S. in 1918, and a Ph.D. in plant physiology in 1923. His formal education was combined with teaching and research, for in 1911 he was appointed assistant pomologist at Cornell, and from 1914 to 1918 he held various positions in the Department of Horticulture at the University of West Virginia. From there he went to the University of Maryland in 1918 as head of its Department of Horticulture and as horticulturist of the Agricultural Experiment Station.

His next ten years were highly productive. He led and conducted research and experimentation in several fields of plant science, with emphasis usually on the underlying principles of plant physiology and biochemistry, but never overlooking the importance of continued advances in practical horticulture. He brought the university's graduate study in horticulture to an ever higher level of development by his constant emphasis on those same basic sciences that he stressed in his own research. Thus, no graduate student in his department majored in "horticulture," but in plant physiology, biochemistry, or plant pathology, commonly with a minor in one of the other two fields. In addition to many scientific papers, it was during this period, too, that he wrote (with H. B. Knapp) two books published in 1929: *Orchard and Small Fruit Culture* and *Growing Tree and Small Fruit*. Both of these are still standard texts.

He was brought to the Bureau of Plant Industry in 1928 to consolidate the various offices then conducting research on fruits and vegetables into a Division of Horticultural Crops and Diseases. In 1935 he was made assistant chief of the bureau and in 1938 he became chief. While with the bureau he continued to stress fundamental research and was active in initiating some of the special investigations dealing with length-of-day response, the plant hormones that were then coming into notice, and similar studies. He was active also in the organization of the Northeast Pasture Laboratory at State College, Pennsylvania; the Soybean Regional Laboratory at the University

of Illinois; the Salinity Laboratory at Riverside, California; and the Plant, Soil and Nutrition Laboratory at Ithaca, New York. The interrelationship of soils with plant nutrition and with animal and human nutrition became a subject of special interest, and he gave an outstanding paper emphasizing the possibilities of research in this field at the annual meeting of the AAAS at Richmond, Virginia, in 1938. In 1942 he was appointed the first administrator of the Agricultural Research Administration, which he had the responsibility of organizing. This was a difficult and bold venture that united many diverse research activities, and it required an imaginative grasp of the ends in view, plus patient diplomacy in achieving them. He held this position until 1945, when he became director and president of the Pineapple Research Institute of Hawaii.

The Plant Industry Station at Beltsville, Maryland, is a monument to Dr. Auchter's administrative ability and to his vision and drive. What if there had been no Beltsville? Let us look back: Arlington Farm was doomed, the West Wing and most of the quarters of the bureau in the South Building were likely to be taken any day, and nowhere were there specific plans for a continuation of the bureau as an entity. Moreover, we were at war, with all the difficulties which that entailed in the procurement of materials and labor for construction. Nor was there any appropriation to expand Beltsville, and the very name was anathema to many of the members of the Congress. Without the knowledge or prior approval of the Secretary of Agriculture or other officials, Gene Auchter alone, working through a friendly senator since retired, got the necessary appropriation. Even earlier, steps were under way to acquire the property needed, and the entire project had been formulated in his mind. It was a privilege to stand on one of the high points in the building area and have Dr. Auchter paint a word picture of just what was to go where. It was also a privilege to hear him dissuade Army officials from demolishing the greenhouses at Arlington until other facilities were available.

Dr. Auchter belonged to many scientific and professional societies. He was an honorary fellow of the Royal Horticultural Society of London, a fellow of the AAAS, and a member of the American Society of Horticultural Science (president, 1926), American Society of Plant Physiologists, American Phytopathological Society, American Genetics Association, Washington Academy of Sciences, Botanical Society of Washington, Botanical Society of Hawaii, Hawaiian Academy of Science (president, 1950), Sigma Xi, Alpha Zeta, and Phi Kappa Phi. He was an officer of and devoted much time to the activities of the Pacific Science Council and was a member of the Cosmos Club (Washington, D. C.).

With all these varied activities and accomplishments in his profession, Gene Auchter, as he was known to hundreds of friends, was first of all human, and he thoroughly enjoyed life. While at college, he earned part of his expenses as a semiprofessional baseball pitcher. A broken finger ended any possible dream of making a career of baseball, but it did not end his interest in the game and in those who played it. About 1936 he rode from Washington to New York with the New York Yankees and ate dinner at the table at which Lefty Gomez sat. His enjoyment was like that of a fourteen-year-old. For days much of his conversation was about the talk he had overheard, particularly of the many different ways Gomez had tried to put an end to a current pitching slump. In later life, time did not permit Dr. Auchter to engage in hunting and fishing, but he retained a sincere interest in these pursuits.

Few, if any, of his intimate friends knew how many graduate students he had helped finance to a final degree. It was heartening, however, to see the pleasure he derived from the knowledge of having helped, when one of his "boys" made good—as most of them did. Always throughout his career he had a keen eye for promising young scientists and liked to encourage them. Perhaps this was one of the secrets of his success. Again, as an officer in Phi Kappa Phi, he devoted time to careful inquiry as to the justification for certain new chapters and to preparations for, and installations of, new chapters when this fell to his lot. Indeed, there seemed to be no end to the vitality and drive that permitted him to enjoy life in all its ramifications.

Dr. Auchter was awarded the Wilder Medal by the American Pomological Society in 1952 for outstanding achievements in horticultural science. We can conclude in no better way than to quote the formal citation inscribed on this medal:

"Scientist, educator, administrator, leader in horticulture, through whose vision and devotion opportunities have been provided for substantial advancement in horticultural research of great benefit to society."

News and Notes

Scientists in the News

Justin M. Andrews has been appointed assistant surgeon general and associate chief of the Bureau of State Services of the U. S. Public Health Service. Dr. Andrews, who is chief of the service's Communicable Disease Center in Atlanta, Ga., will be replaced by **Theodore J. Bauer,** now chief of the Division of Venereal Disease, in Washington, D. C.

J. H. Bruun has joined Hooker Electrochemical Company as director of research. Dr. Bruun had been with General Aniline and Film Corporation for ten years.

Lewis M. Clement, of the Crosley Division, AVCO Manufacturing Corporation, has been appointed chairman of the recently formed Advisory Group on Reliability of Electronic Equipment, Research and Development Board. **Henry Randall** has been named executive director of the RDB Committee on Electronics, of which he has been acting executive director.

S. Douglas Cornell has been appointed executive officer of the National Academy of Sciences–National Research Council. Dr. Cornell, who assumed his duties on Nov. 20, has been director of the RDB Planning Division.

Gustave J. Dammin, chairman of the Pathology Department of Washington University Medical School and pathologist-in-chief of Barnes Hospital, St. Louis, will take up new duties this month as professor of pathology in the Harvard Medical School and pathologist-in-chief of Peter Bent Brigham Hospital. He succeeds **Clinton Van Zandt Hawn,** who has resigned for reasons of health.

Howard S. Gay, chief of engineering planning, North Atlantic Division of the Army Corps of Engineers, has resigned after 46 years of professional service. He planned such projects as the St. Lawrence Seaway, the Austin (Tex.) Dam, and the electrification of St. Croix in the Virgin Islands.

Thomas H. Hunter, associate dean of Washington University School of Medicine, has been named dean of the University of Virginia School of Medicine, to succeed **Vernon W. Lippard,** who will become dean of medicine at Yale. Dr. Hunter will take up his new position Feb. 1.

Under an international exchange program, a Swedish research engineer, **Pelle Isberg,** has replaced **Arthur Waltner,** associate professor of physics, at North Carolina State College. Dr. Waltner has assumed Professor Isberg's duties in Sweden for a year. Before joining the State College staff, Dr. Isberg was with the Swedish Atomic Energy Company.

John W. Nason, former president of Swarthmore College, has resigned to become president of the Foreign Policy Association, Inc. He succeeds **Brooks Emeny,** who resigned in November, but who remains as a member of the board.

Jerome S. Peterson, of New York City, has been made director of the Division of Public Health Services at the Geneva headquarters of WHO. Since 1949 Dr. Peterson has directed health services for Palestine refugees in Lebanon, Syria, Jordan, the Gaza area, and Israel.

John D. Rockefeller 3d has been elected chairman of the board of the Rockefeller Foundation. He succeeds **John Foster Dulles,** who resigned following his appointment as Secretary of State.

H. N. Rydon, who has been appointed to the chair of chemistry at the Manchester College of Technology, succeeds **J. Kenner,** who has been made emeritus professor. Dr. Rydon was a member of the scientific staff of the Medical Research Council Unit for Bacterial Chemistry, working at the Lister Institute. In 1947, however, he returned to academic work as reader in organic chemistry at Birkbeck College, University of London; in 1949 he became assistant professor and reader in organic chemistry at the Imperial College, where he has been responsible for the organization and general supervision of the advanced practical exercises in organic chemistry forming part of the new undergraduate course of study.

Thorndike Saville has left for London as head of a group from the U. S. that will present the views of this country on "Engineering Education" at a conference sponsored by the engineering societies of Western Europe and the United States.

D. B. Steinman has been elected president of the New York Academy of Sciences to succeed **George B. Pegram.** Dr. Steinman is a life fellow of the academy and was one of the founders of its Section on Mathematics and Engineering.

Conrad Van Hyning has been appointed executive director of the American Social Hygiene Association. He was formerly general director of the National Travelers Aid Association.

Nils Y. Wessell, vice president of Tufts College, has been named acting president to fill the vacancy caused by the resignation of **Leonard Carmichael,** who will become head of the Smithsonian Institution.

Carl J. Wiggers, head of the Department of Physiology at the School of Medicine of Western Reserve University, will retire next June after 35 years of service. He will devote full time to editing the new journal *Circulation Research,* a bimonthly publication of the American Heart Association. The first issue of the journal will appear in January.

Education

The **University of Chicago** will compile an inventory of knowledge in the field of economic development with a $35,000 grant received from the Ford Foundation. Bert Hoselitz, associate professor of social sciences and director of the university's Research Center on Economic Development and Cultural Change, will be in charge of the project.

The following faculty changes have been made at the **University of North Carolina:** A. Price Heusner, of Boston University Medical School, was named professor of neurosurgery; David Davis, of the Medical College of Georgia, was named professor of anesthesiology and director of the anesthesiological service in Memorial Hospital. Appointed to assistant professorships were Charles E. Flowers, Jr., of the State University of New York College of Medicine; William P. Sprunt III, of Harvard Medical School; and Alberta Margaret Beat, of the University of Washington School of Dentistry. Bernard G. Greenberg was made professor and head of the Department of Biostatistics in the School of Public Health, and Wasily Hoeffding was made associate professor. Reuben Hill, professor of sociology, was granted a year's leave of absence to serve as director of family life research and visiting professor in the University of Puerto Rico. Jack H. Brown, assistant professor of physiology, resigned as of Nov. 15.

The **University of Wisconsin** McArdle Memorial Laboratory for Cancer Research now offers a course of study and research leading to the Ph.D. degree. Major emphasis will be on biochemistry. Adequate training in chemistry is stressed as a prerequisite. Applications for research assistantships must be received prior to *Mar. 15* or *June 15* for work starting on July 1 or Sept. 1, respectively. Full information may be obtained from H. P. Rusch, of the laboratory.

Grants and Fellowships

The **Ford Foundation Board on Overseas Training and Research,** 575 Madison Ave., New York 22, is offering a number of foreign study and research grants to U. S. citizens under 35 who wish to begin or to continue study or research concerning Asia, or the Near and Middle East. Applications must be returned before *Jan. 31.*

Applications for the **Daniel and Florence Guggenheim Foundation Jet Propulsion Fellowships** for graduate study in rocket and jet propulsion engineering are now being accepted. Training will be given at Princeton University and California Institute of Technology. Full information may be obtained from the foundation, 120 Broadway, New York 5. *Mar. 1* is the deadline for receipt of applications.

Bryn Mawr College has established the **Helen Schaeffer Huff Memorial Research Fellowship,** which will carry a stipend of $3200. Women who hold a doctor's degree and who wish to do research in physics or chemistry should apply to the dean before *Mar. 15.*

The **New York Zoological Society** has grants-in-aid available for the summer research program at its Jackson Hole Research Station. The program will include studies in ecology, animal behavior, and land management and related fields. For application blanks and further information address the director, Jackson Hole Research Station, Moran, Wyo.

In the Laboratories

Aluminum Company of America has announced plans to build a $3,000,000 plant in the Lancaster (Pa.) area for the fabrication of aluminum screw machine products, fasteners, rivets, and nails. Construction will require 12 to 15 months. ALCOA recently opened a $45,000,000 smelting works near Wenatchee, Wash., which is expected to be in full operation early in 1953.

Cornerstone for the new **Henry W. and Albert A. Berg Institute for Experimental Physiology, Surgery and Pathology** at the New York University–Bellevue Medical Center was laid on Dec. 3. As part of the ceremony, a check for $500,000 for construction of the institute was presented by a representative of the estate of the late Albert A. Berg. The institute is named for Dr. Berg and his elder brother.

Buffalo Electro-Chemical Co., Inc., has elected Max E. Bretschger president to fill the vacancy created by the death of Charles A. Buerk. Frederick A. Gilbert, former manager of BECCO's Vancouver plant, was elected vice president.

Dewey & Almy Chemical Company will install Hugh S. Ferguson as president on Jan. 1 when Bradley Dewey, president since the company's founding in 1919, retires. Mr. Ferguson has been with D&A 28 years and has been executive vice president since 1948.

A new **Fatigue Testing Laboratory,** recently opened by Lord Woolton at the Engineering Research Station, Abington, near Cambridge, England, will carry on fatigue testing of welded structural components, an important part of the work of the British Welding Research Association. The new laboratory is of technical interest in itself, since it is the first building to be erected for which the plastic design method, originated by J. F. Baker, has been applied. In parallel with the full program of fatigue testing at present being carried out by the laboratory staff, studies are being made of the mechanics of crack propagation, the phenomenon that is fundamental to brittle and fatigue structural failures.

Harvey Laboratories, manufacturing chemists, have moved to new, larger quarters at 5102 Germantown Ave., Philadelphia.

Meetings and Elections

The **American Chemical Society** Division of Agricultural and Food Chemistry has elected Arthur N. Prater chairman, succeeding Asger F. Langlykke. C. S. Boruff was chosen chairman-elect, and D. M. Doty was named secretary-treasurer. The Division of Industrial and Engineering Chemistry has elected J. Henry Rushton chairman to succeed Melvin C. Molstad. C. J. Krister is chairman-elect, and Edmond L. d'Ouville was elected secretary-treasurer. Other elections include that of Arthur K. Doolittle to the chairmanship of the Division of Paint, Plastics and Printing Inks Chemistry to succeed Francis Scofield, and Albert C. Zettlemoyer as vice-chairman. John K. Wise was named chairman-elect, and C. F. Brown secretary-treasurer. The Division of Rubber Chemistry elected Seward G. Byam chairman, succeeding Waldo L. Semon, and re-elected Charles R. Haynes and Amos W. Oakleaf secretary and treasurer, respectively. James C. Walton was named vice-chairman.

The **American Institute of Chemical Engineers** has elected William T. Nichols president for 1953. Dr. Nichols is director, General Engineering Department, Monsanto Chemical Co. Chalmer G. Kirkbride, of Houdry Process Corporation, was elected vice president, and Stephen L. Tyler and C. R. DeLong were re-elected executive secretary and treasurer, respectively. J. Henry Rushton, of Illinois Institute of Technology, received the William H. Walker Award of the institute in recognition of his "excellent publication record over the years in the fields of equipment design, mechanical mixing, and engineering education." Thomas Baron, of Shell Development Company, and Lloyd G. Alexander, of Oak Ridge National Laboratory, received the 1952 Junior Award, given annually for outstanding contributions to the literature of chemical engineering.

The **American Institute of Mining and Metallurgical Engineers** has elected Andrew Fletcher president to succeed Michael L. Haider. Mr. Fletcher, president of the St. Joseph Lead Company, will take office in February. Leo F. Reinartz was named president-elect. New vice presidents elected were L. E. Elkins and A. B. Kinzel.

Personnel from industrial concerns, universities, hospitals, and government laboratories using x-ray and radioisotopes in the area have formed the **Cincinnati Radiation Society,** of which the following are serving as officers for 1952–53: chairman, Eugene L. Saenger; vice chairman, Leonard E. Rasmussen; secretary, Robert G. Gallagher; treasurer, Mitchell R. Zavon.

The **International Commission on Zoological Nomenclature** has elected James C. Bradley, professor emeritus of entomology, Cornell University, president to succeed the late James Lee Peters. Dr. Bradley has been one of the U. S. representatives on the commission since 1944.

An **International Symposium on Neurosecretion** is to be held at the Stazione Zoologica, Naples, in May. Special emphasis will be on the physicochemical properties of neurosecretion, passage of neurosecretions along the nerve fibers, and their hormonal activities in different groups of vertebrates and invertebrates. Further details may be obtained from P. Dohrn, of the Stazione Zoologica.

The **Lancaster Branch, AAAS,** will present Ray F. Dawson, of Columbia University, in a lecture on "Some Vantage Points in Modern Botanical Research" Jan. 8; Arthur A. Allen, of Cornell University, on "The Bird's World and the Bird's Year," Feb. 6; and Wilton M. Krogman, of the University of Pennsylvania, on "The Record of Life and Death in the Bones," Mar. 5. Hubert Wilkins spoke at the Nov. 6 meeting, and Willy Ley on Dec. 4.

Operations Research Society of America, formed earlier this year, held its first national meeting at the National Bureau of Standards Nov. 17–18. Among the subjects discussed were the Monte Carlo method; waiting times, supply lines, and fluctuation theory; selection of the proper criterion against which to weigh the value of alternative methods; aircraft maintenance; and operations research in industry and agriculture. Philip M. Morse, of MIT, is first Operations Research president.

The **Society of Rheology** held its annual meeting at the Franklin Institute in October. The Bingham Medal, established in honor of the society's founder, the late E. C. Bingham, of Lafayette College, was awarded to A. L. Nadai of Budapest, for his outstanding work on the elasticity, plasticity, and flow properties of metals. Dr. Nadai has recently come to this country from the University of Göttingen and has taken a post at Westinghouse Electric Corporation, Pittsburgh, as consulting mechanical engineer.

Under the sponsorship of **Southwest Research Institute,** a two-day regional symposium on architectural acoustics will be held in San Antonio Jan. 15–16. C. A. Culver, senior physicist at Southwest Research, is in charge of arrangements.

The **Tennessee Academy of Science,** at its 62nd meeting, elected the following officers: president, A. J. Sharp; vice president, M. S. McCay; secretary, Isabel H. Tipton; and treasurer, J. W. White. Don Miller, of Nashville, and Jennifer Tipton, of Knoxville, were recommended for AAAS awards for the best papers presented in the Junior Academy meeting.

United States Steel Corporation has elected Clifford F. Hood president to succeed Benjamin F. Fairless. Harvey B. Jordan, now president of American Steel and Wire, was elected executive vice president, and Howard E. Isham was elected vice president and treasurer to succeed Max D. Howell, who has retired to assume new duties as executive director of the American Iron and Steel Institute.

Technical Papers

Infrared Spectra of Pneumococcal Polysaccharides[1]

Heber J. R. Stevenson and Seymour Levine

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It has been demonstrated that dried films of bacteria of various genera, species, and even types have characteristic infrared absorption spectra (*1*). In an effort to correlate the spectral differences with cytochemical structures, we have reported studies of the spectra of various extracts of bacteria, as well as the effect of the whole cell spectrum of certain extraction procedures (*2*).

Spectra of purified pneumococcal polysaccharides appear to be of sufficient interest to warrant a preliminary report. These substances are of especial interest since they determine the serological type specificity of the whole cell and have been reasonably well characterized as to chemical structure.

Samples of the polysaccharides were prepared by evaporating aqueous solutions to dryness on the surface of silver chloride plates. By constructing a holder for very small silver chloride plates to be used in the microcell adapter of the Perkin-Elmer double-beam recording spectrophotometer, satisfactory spectra were obtained from 0.4 mg. A somewhat thinner film was useful to bring out more detail between 8.5 and 10 μ where the absorption is very strong. The spectrum from 2 to 15 μ can be automatically recorded in 40 min.

The spectra of some of the pneumococcal polysaccharides are shown in Fig. 1. The spectra of Types I,

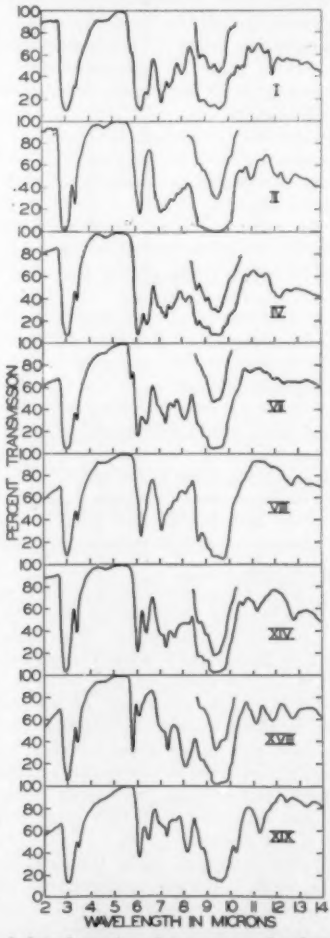

FIG. 1. Infrared spectra of pneumococcal polysaccharides. Types I, II, IV, and XIV were obtained from Dr. Brown and Types VII, VIII, XVIII, and XIX from Dr. Palmer.

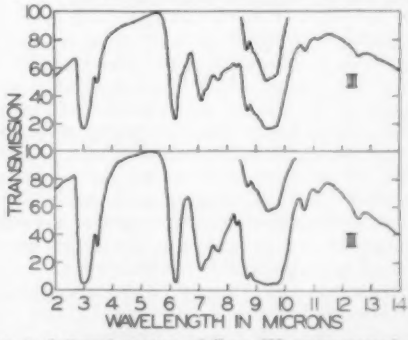

FIG. 2. Infrared spectra of Type III pneumococcal polysaccharides obtained from Dr. Palmer (upper spectrum) and Dr. Brown (lower spectrum).

IV, VII, XIV, XVIII, and XIX are quite distinctive and easily identified. On the other hand, the spectra of Types II, III, and VIII are similar, although definitely distinguishable. These spectral relationships are in accord with the analytical data reported in the literature (*3*) which indicate that Types II, III, and VIII are chemically similar in having a low content of nitrogen, phosphorus, and acetyl groups and in giving positive tests for glucose and uronic acid.

Spectra of two samples of Type III polysaccharide obtained from different sources and prepared by different methods are shown in Fig. 2. Small differences are present, but these are of a lesser order of magnitude than the differences between Type III and any other type.

These preliminary results indicate some of the uses

[1] We are indebted to Rachel Brown, of the New York State Department of Health, and to John W. Palmer, of E. R. Squibb & Sons, for the polysaccharides used in this study.

of infrared spectrophotometry in immunochemistry: (1) It affords a single, rapid physical test, requiring a small sample of the purified material, which permits the identification of the type-specific polysaccharides. (2) By comparison with standard samples, it may be used as a criterion of purity. (3) Comparison of the spectra of different types provides information on chemical structure and relationships.

A more complete report on this work will be published elsewhere.

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Manuscript received June 9, 1952.

The Occurrence of Lymphocytes with Bilobed Nuclei in Cyclotron Personnel[1]

M. Ingram, M. Adams, L. Coonan, J. Jespersen, G. Nielsen, D. Piatt, and G. Yettewich[2]

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A preliminary report of observations on the blood of cyclotron workers at the 130″ cyclotron at the University of Rochester called attention to an increased incidence of lymphocytes with bilobed nuclei in cyclotron personnel during the early period of operation of the cyclotron (*1*). It has recently been possible to review the data representing the period extending from 1948, when the initial crew was being formally assembled, through 1951. This review is the subject of the present report. Interest in this subject has been sustained by experimental confirmation of the relationship between an increased number of lymphocytes with bilobed nuclei and exposure to very small amounts of radiation from the cyclotron (*2*).

Hematological monitoring was instituted as a part of the health program for cyclotron personnel in July 1948. The institution of this program prior to the completion of the cyclotron presented a distinct advantage in evaluating the significance of subsequent observations since it permits quantitative comparison of data for the same individuals collected during the control and working periods, as well as comparison of control data for various groups of workers. Throughout the period of cyclotron operation all new employees have had duplicate or triplicate blood studies within 7–10 days after hire, and this has resulted in an ever-expanding body of control data. In most instances, RBC and WBC counts have been done in duplicate, and differential leukocyte counts are based upon examination of 200 leukocytes on a Wright's stained smear. Hemoglobin determinations and platelet counts were done by standard procedures. Throughout the program, particular emphasis has been placed on the cytology of peripheral blood. The basic procedure has been extensive study of good coverslip blood smears of capillary blood. Peroxidase staining was introduced as a routine procedure after the first few cells which appeared to be binucleate lymphocytes were noted. Peroxidase-stained smears are examined from edge to edge, the leukocytes in all good areas counted, and the number and position of all lymphocytes with bilobed nuclei noted. Each cell is subsequently "edited" by the entire group concerned with this study in order to verify the classification. Currently three pairs of peroxidase-stained smears (approximately 8000 leukocytes) are examined for each new employee.

In addition to hematological studies, a complete medical history, as well as the results of physical examinations, is recorded in considerable detail for each individual at the time of hire. A cordial relationship between the cyclotron personnel and the Health Service group facilitated evaluation of the general health of the various individuals during the period covered in this report.

The first evidence of an increased incidence of the abnormal lymphocytes in cyclotron workers was provided by two incidents which occurred during the early days of cyclotron operation. In the first, four physicists were in the cyclotron building when the man at the control panel made certain adjustments that resulted in the possibility that the physicists might have had some slight exposure to the beam.[3] Blood studies were done daily on these four men during the following two weeks and, for the first time in our experience, the presence of several lymphocytes with bilobed nuclei was noted.

Shortly after this, construction of an earth and concrete dike between the cyclotron building and the cyclotron laboratory was begun. This was nearing completion in March 1949, when the second incident occurred. While the cyclotron was running, two machinists started out the back door of the shop in the laboratory building toward the building housing the cyclotron. The men had reached the far end of the dike about 50 feet from the cyclotron building before they realized their mistake and hastily retraced their steps. It was estimated that they were outside the shop only a few minutes.

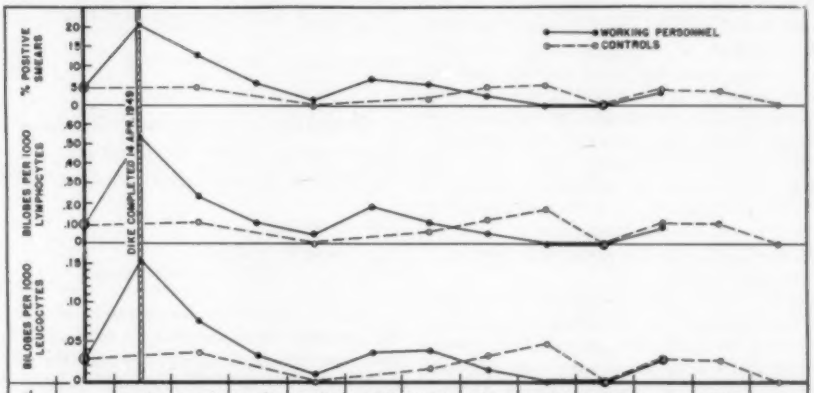
The two men developed slight, transient leukopenia during the week following exposure, and showed a definite increase in lymphocytes with bilobed nuclei for about three weeks after exposure. Seven control

[1] This paper is based on work performed under contract with the U. S. Atomic Energy Commission at the University of Rochester Atomic Energy Project, Rochester, N. Y.

[2] The authors wish to express their appreciation for the unusually generous cooperation of S. W. Barnes, and the entire cyclotron crew in carrying out the studies on which this report is based.

[3] Both incidents occurred prior to the installation of the various mechanical safety devices which have long since made it virtually impossible for anyone to be in the cyclotron building or the fenced-in cyclotron area while the cyclotron is running.

smears (approx 12,000 leukocytes) from the two men before the incident contained no lymphocytes with bilobed nuclei. By contrast, 11 of 40 smears (28%) pulled during the first 3 post-exposure weeks were positive for binucleate lymphocytes, the incidence in terms of leukocytes being 18/48,000, or roughly 0.4 lymphocytes with bilobed nuclei/1000 leukocytes, or 1.1/1000 lymphocytes (*cf.* Fig. 1). At the time of the incident the men were not wearing badges, a circumstance typical of situations in which biological monitoring is highly desirable. Largely as a result of these two incidents it was decided to review complete blood smears of the entire group, with the idea of obtaining additional information relative to the possible significance of lymphocytes with bilobed nuclei as indicators of radiation exposure.



INTERVAL		CONTROL	JAN.'49 THRU APR.14'49	APR.15'49 THRU JULY'49	AUG.1'49 THRU OCT.'49	NOV.'49 THRU JAN.'50	FEB.'50 THRU APR.'50	MAY'50 THRU JULY'50	AUG.'50 THRU OCT.'50	NOV.'50 THRU JAN.'51	FEB.'51 THRU APR.'51	MAY'51 THRU JULY'51	AUG.'51 THRU OCT.'51	NOV.'51 THRU JAN.'52
INDIVIDUALS	W	44	44	39	34	18	11	34	26	18	3	34	—	—
	N	44	—	24	—	16	—	12	15	9	11	11	12	9
SMEARS EXAMINED	W	82	160	151	141	49	28	92	62	23	3	50	—	—
	N	82	—	161	—	58	—	42	55	35	28	22	23	23
WBC EXAMINED (Thousands)	W	173	857	728	500	203	110	356	249	31	6	72	—	—
	N	173	—	89	—	91	—	58	98	46	38	36	38	34

W - WORKING PERSONNEL N - NEW HIRE (CONTROLS) *W & N IDENTICAL

FIG. 1. Incidence of lymphocytes with bilobed nuclei in cyclotron personnel.

The results of the completed survey are shown in Fig. 1. The incidence of binucleate lymphocytes is presented as (1) the incidence of positive smears (smears which contains one or more of these cells), (2) the number of binucleate lymphocytes/1000 leukocytes examined, and (3) the number of binucleate lymphocytes/1000 lymphocytes examined. Since it was considerably more expedient to keep track of the number of leukocytes rather than the differential count on an entire peroxidase-stained smear, the number of binucleate lymphocytes/1000 lymphocytes is based on an approximation of the number of lymphocytes examined, arrived at by multiplying the number of leukocytes examined during the interval under consideration by the average percentage of lymphocytes found on routine differential counts during that interval. The control data represent the incidence of the unusual lymphocytes in the initial studies of new individuals.

It will be noted that a definite increase of lymphocytes with bilobed nuclei occurred in the group as a whole during the early periods of cyclotron operation. The maximum does not include the incidence in any of the personnel involved in the events mentioned above. Findings in these persons were excluded from the data on the group as a whole for a period of several months after each incident. Since the completion of the protective dike, the number of smears containing one or more lymphocytes with bilobed nuclei has returned to a level about equal to that for the control group. The average leukocyte counts and absolute granulocyte and absolute lymphocyte counts for the group remained relatively stable throughout the period under consideration.

Unusually high numbers of cells with double nuclei have been observed in several tissues following exposure to relatively small doses of ionizing radiation (*3, 4*) and it is not particularly surprising that lymphoid tissue, which is known to be highly radiosensitive, should show a similar response. The findings presented here are directed particularly to the attention of persons concerned with the prevention of radiation

injuries, because (1) the increased occurrence of binucleate lymphocytes appears to be related to exposure to exceptionally small amounts of radiation, and (2) lymphocytes may readily be obtained for examination. Hence examination for the presence of these cells serves as a practicable and sensitive adjunct to physical monitoring when circumstances indicate the desirability of biological monitoring.

Observation of an occasional lymphocyte of this type in irradiated animals and man has been reported by other investigators (*5*, *6*). Quantitative estimates of pre- and post-exposure incidence, however, had not been made in these instances; hence it has not been possible to evaluate the significance of radiation exposure as regards the appearance of the cells. Unpublished reports suggest, however, that the cells are observed not uncommonly in radiation workers in other institutions—specifically in a "hazard group" at Los Alamos (*7*) and among luminizers in England (*8*). In both cases, exposure has apparently been kept below the current tolerance level.

It is likely that the increased incidence of lymphocytes with bilobed nuclei in the blood of cyclotron personnel during the early days of cyclotron operation actually indicates exposure to very small amounts of radiation, although physical monitoring at that time did not identify the nature and extent of exposure, and in fact has consistently indicated that exposure is well below tolerance. The supposition that the increased incidence of binucleate lymphocytes represents an effect of irradiation is supported by previously published experimental results (*2*) in which dogs, after a long control period, were exposed three times, 30 min each time, in positions approximating those reached by the two machinists described above. After each exposure there was a marked increase of lymphocytes with bilobed nuclei, followed by a gradual return to approximately normal levels during the period of approximately 2 months between exposures.

Lymphocytes with bilobed nuclei may appear in increased numbers in conditions other than exposure to ionizing radiation, as, for example, in infectious processes and in leukemia. The occurrence of an occasional cell of this type in the controls may reflect the normal incidence of low-grade infections in the group as a whole. It should be mentioned that the general health of the group remained good throughout the period under consideration. In particular, there was no indication of an unusual number of infections to explain the observed increased incidence of lymphocytes with bilobed nuclei during the first few months of cyclotron operation.

Since the occurrence of lymphocytes with bilobed nuclei remained low after completion of the protective dike, the detailed examination of peroxidase-stained smears is currently carried out only for new employees or when there is some definite change in operating procedure (e.g., reversal of the beam) or some question of personnel exposure. In such instances, the growing group of control observations and the individual's own control (new-hire) data are of great value.

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A Quantitative Study of Folic Acid Requirements and Reversal of Aminopterin Inhibition in *Drosophila*[1, 2]

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Studies reported by Goldsmith *et al.* (*1*) regarding the response of *Drosophila* to folic acid antagonists made use of a medium for growing the larvae which contained live yeast. This precludes the collection of exact quantitative data. The present report is concerned with results obtained (Table 1) with Drosophila reared on a chemically defined medium (*2*) and under aseptic conditions. With these last-named parameters controlled, the effect on growth of very precise amounts of a test substance can be determined.

Using the Oregon-R wild type strain of *D. melano-*

TABLE 1

Base medium (mg/ml)			(gamma/ml)
L-alanine	1.085	Biotin	0.020
L-arginine	0.794	B_{12}	0.04
L-aspartic acid	1.221	Ca-pantothenate	6.0
L-cystine	0.480	Choline chloride	20.0
L-glutamic acid	4.418	Pyridoxine	3.0
Glycine	2.328	Riboflavin	2.4
L-histidine	0.484	Thiamine	1.5
L-hydroxyproline	0.384	Niacinamide	10.0
L-isoleucine	1.260		
L-leucine	2.345		(mg/ml)
L-lysine	1.337	$MnSO_4 \cdot 4H_2O$	0.246
L-methionine	0.339	$MgSO_4 \cdot 7H_2O$	0.0129
L-phenylalanine	1.008	$FeSO_4$	0.0129
L-proline	1.682	KH_2PO_4	0.606
DL-threonine	1.512	K_2HPO_4	0.606
L-tryptophane	1.745	Thymine	0.004
L-tyrosine	1.240	NaCl	0.0129
L-valine	1.355	$CaCl_2$	0.0129
Sucrose	7.5	Agar	15.0
Cholesterol	0.1	Ribonucleic acid	1.0
Ergosterol	1.0	Inosine	0.25

[1] This investigation was supported by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council.

[2] G. W. Kidder, of Amherst College, kindly furnished the analogs used.

TABLE 2

TWO DOSE-RESPONSE TESTS TO PTEROYLGLUTAMIC ACID

PGA (milligamma/ml)	Original No. larvae		% Larvae to pupate		Av time in days to pupation		% Pupae to become adults	
	#1	#2	#1	#2	#1	#2	#1	#2
6000.00	15	19	80.0	100.0	10.7	10.4	100.0	100.0
300.00	12	17	50.0	100.0	11.2	10.8	100.0	100.0
150.00	12	17	58.3	94.1	11.0	10.9	100.0	100.0
75.00	9	—	55.6	—	11.8	—	80.0	—
30.00	13	8	46.2	100.0	11.7	11.6	33.3	75.0
15.00	18	10	50.0	100.0	14.3	12.5	0.0	20.0
7.50	15	10	20.0	60.0	14.3	13.5	33.3	0.0
3.00	15	10	13.3	30.0	16.0	15.2	0.0	0.0
1.50	14	—	0.0	—	—	—	0.0	—
0.75	16	18	0.0	0.0	—	—	0.0	0.0
0.15	18	9	0.0	0.0	—	—	0.0	0.0
0.00	9	8	0.0	0.0	—	—	0.0	0.0

gaster, two dose-response tests to folic acid (pteroylglutamic acid, PGA) were carried out to determine the minimal and optimal amounts necessary for growth (Table 2). The minimal amount of PGA that will support any development beyond the larval stage was determined to be between 1.5 and 3.0 milligamma/ml medium; the optimal was the highest concentration used (6000 milligamma/ml), but 30 milligamma/ml may be considered to give only slightly suboptimal development.

A preliminary investigation was made of several of the analogs of PGA to determine their effectiveness in the replacement of PGA. Tests were run on synthetic folinic acid (citrovorum factor), teropterin (pteroyltriglutamic acid, PTGA), and aminopterin (4-aminopteroylglutamic acid). The first two were found to be capable of replacing PGA; the latter inhibited development (Table 3).

On the basis of molecular weight, amounts were used of PTGA and of the citrovorum factor comparable to 75 milligamma/ml of PGA. At least in the amounts used, neither the citrovorum factor nor PTGA were quite as effective in fulfilling the growth requirements of Drosophila, using time to pupation as the criterion, although the difference does not appear to be significant. Higher concentrations of citrovorum and PTGA were not tested.

TABLE 3

ATTEMPTS TO REPLACE PTEROYLGLUTAMIC ACID

	Original No. larvae	% Larvae to pupate	Av time in days to pupation	% Pupae to become adults
PGA (75 milligamma/ml)	68	92.6	11.7	96.8
PGA (6000 milligamma/ml)	41	82.9	10.8	91.2
Citrovorum (10 u/ml)	53	96.2	12.6	100.0
PTGA (122 milligamma/ml)	66	98.9	12.1	100.0
Aminopterin (3 milligamma/ml)	19	0.0	—	0.0

TABLE 4

AMINOPTERIN INHIBITION RELEASED BY VARIOUS AMOUNTS OF PGA
(Aminopterin, 3 milligamma/ml)

PGA (milligamma/ml)	Original No. larvae	% Larvae to pupate	Av time in days to pupation	% Pupae to become adults
9,600.0	24	87.5	10.8	100.0
8,200.0	25	96.0	10.9	87.5
4,800.0	26	100.0	10.7	92.3
2,880.0	28	85.7	10.9	100.0
480.0	23	91.3	10.9	100.0
144.0	26	92.3	11.3	95.8
82.0	20	85.0	11.9	70.6
14.4	24	0.0	—	0.0

Since the substitution of aminopterin gave no growth, it was of interest to see if it actually inhibited or could not be utilized by the organism. Therefore, various concentrations of aminopterin were put into the medium in the presence of a slightly suboptimal concentration of PGA (30 milligamma/ml). All concentrations of aminopterin prevented development. Only the control with no aminopterin grew. The concentrations of aminopterin tested were, in milligamma/ml: 3, 100, 300, 750, 1500, and 3000, with an average of 24.5 original larvae at each concentration. It could therefore be concluded that the action of aminopterin is that of an antagonist to PGA.

Studies were then made of the ability of PGA to release the inhibition caused by aminopterin. For this purpose, a small amount of aminopterin (3 milligamma/ml, shown to be inhibitory in the previous experiment) and increasing amounts of PGA were used. The results (Table 4) show that PGA is able to release the inhibition, in part, when it is present in a concentration as low as 82.0 milligamma/ml

TABLE 5

INCREASING AMOUNTS OF AMINOPTERIN IN THE PRESENCE OF 6000 MILLIGAMMA PGA/ML

Aminopterin (milligamma/ml)	Original No. larvae	% Larvae to pupate	Av time in days to pupation	% Pupae to become adults
0	10	100.0	11.2	90.0
3	21	100.0	11.0	100.0
100	20	95.0	11.5	100.0
1000	18	11.1	16.0	0.0

and to release it completely at 480.0 milligamma/ml.

This experiment showed that the inhibition caused by a small amount of aminopterin could be released by a slightly suboptimal amount of PGA. It was decided next to see how much aminopterin could be used without an inhibiting effect in the presence of an optimal amount of PGA. The results of these tests are presented in Table 5.

The results presented in Table 5 show that amounts of aminopterin as high as 100 milligamma/ml can be used without showing marked inhibition if the amount of PGA is also high. Even when 1000 milligamma of aminopterin/ml medium was used, complete inhibition was not achieved in the presence of 6000 milligamma PGA.

An inhibition index can be calculated which is quite consistent if one takes the concentration of inhibitor necessary to produce only half maximum growth (50% pupation), and obtains the ratio of it to the concentration of the metabolite used. In Table 4, it can be seen that 50% pupation occurs somewhere between a concentration of PGA of 14.4 and 82.0 milligamma/ml when the concentration of aminopterin is 3. Assuming that 50% pupation would occur with roughly 35 milligamma/ml PGA, the ratio of inhibitor to metabolite would be 3/35, or 0.086. If the same treatment is given to the data in Table 5, the ratio is 500/6000, or 0.083. These two values are remarkably close, indicating a constant relative inhibitive effect of aminopterin to the concentration of PGA.

Using a chemically defined medium in the absence of microorganisms, the quantitative results are of a different order of magnitude. This is strikingly illustrated by comparing the concentrations used by Goldsmith *et al.* (*1*) in a yeast medium with the concentrations found adequate in the present work on a synthetic medium. To obtain complete inhibition by aminopterin, the former workers had to use 75,000 to 200,000 milligamma/ml, whereas in the present work, 3 milligamma/ml was shown to be completely inhibitory. Nevertheless, the two sets of data agree qualitatively.

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Reversal of *p*-Aminobenzoic Acid Inhibition of Growth of Rickettsiae by *p*-Hydroxybenzoic Acid in Agar-Slant Tissue Culture

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The rickettsiostatic action of *p*-aminobenzoic acid (PABA) was first observed in mice by Snyder, Maier, and Anderson (*1*) in 1942 and also in the chick embryo by Greiff, Pinkerton, and Moragues (*2*) in 1944. Independently, Takemori (*3*) found in 1944 (published in 1949) the inhibitory action of PABA on the growth of typhus rickettsiae in tissue culture. It was argued that "if the mode of action of PABA on typhus rickettsiae be similar to that of the action of the sulfonamides on sulfonamide-sensitive organisms, it is suggested that an 'essential metabolite' will be found for rickettsiae which reverses the inhibitory action of PABA on typhus rickettsiae and may be chemically related to PABA" (*3*).

Following the announcement of *p*-hydroxybenzoic acid (POB) as a bacterial vitamin required by a mutant of *Escherichia coli* (*4*), the mechanism of inhibition of *E. coli* by PABA was shown to depend on competition with POB (*5*). The competition between POB and PABA observed with *E. coli* has led to similar reversal studies with POB of the rickettsiostatic action of PABA in chick embryos and mice (*6*).

In view of the rickettsiostatic action of PABA observed in tissue culture by Takemori (*3*), it has seemed desirable to investigate whether this action of PABA is also reversed in *in vitro* growth tests by POB. The present study shows that POB is able to reverse the rickettsiostatic action of PABA in agar-slant tissue culture.

The Wilmington strain of murine typhus (*Rickettsia typhi*), Smith strain of Rocky Mountain spotted fever (*R. rickettsii*),[1] M.K. strain of rickettsialpox (*R. akari*),[1] Nine Mile strain of Q fever (*Coxiella burnetii*),[1] and 6BC strain of psittacosis virus[1] which were employed in these experiments have been maintained on Zinsser's agar-slant culture (*7*) with dark embryonic tissue. All these agents grew quite satisfactorily on this medium, and passages were made at 8–15-day intervals.

The medium was prepared as described previously for the cultivation of rickettsiae and the viruses of lymphogranuloma venereum and tick-borne encephalitis (*8*). A 3.5% agar solution is made in twice-distilled water, dissolved at 15 psi for 15 min, cooled, and kept at about 55° C. To 75 ml of a double-strength Tyrode solution are added 50 ml of horse serum and 4 ml of a 0.04% solution of phenol red. This Tyrode-serum mixture is filtered through a Seitz filter, warmed to 55° C, and mixed with 75 ml of 3.5%

[1] Obtained through the courtesy of Rocky Mountain Laboratory, R. J. Huebner, H. R. Cox, and K. F. Meyer, respectively.

agar. The mixture is then poured into ordinary test tubes in 8–10 ml amounts. The tubes are slanted, left to harden at room temperature, then stoppered with rubber stoppers and sealed with paraffin. The pH of the medium is 7.6–7.8. Either PABA alone or PABA together with POB in various proportions was included in this medium by dissolving in Tyrode-serum mixture before filtration through a Seitz filter, previously washed thoroughly with distilled water. The agar powder employed was washed successively with 50% and 95% ethanol.

Agar-slant culture rickettsiae and virus were used as inocula. Tissue fragments (about 15 mg) from one culture tube showing maximum growth were collected with a spatula, mixed in a short test tube (15 × 80 mm) with about one g of tissue of 9–10 day-old chick embryo from which eyes and legs had been removed. The tissue was then minced well with scissors and deposited with a spatula upon the agar media, each culture tube receiving 60–70 mg of the tissue. Infective material obtained from one culture tube was usually used to inoculate fresh chick embryonic tissue for 12 new cultures, consisting of both control and test media.

The cultures were incubated at 35° C for 7–15 days, and growth was examined microscopically in Macchiavello-stained smears of cultured tissue.

TABLE 1

REVERSAL BY POB OF THE RICKETTSIOSTATIC ACTION OF PABA IN AGAR-SLANT TISSUE CULTURE

Medium		Growth after 8–15 days				
PABA (mg/100 ml)	POB (mg/100 ml)	*Rickettsia typhi*	*Rickettsia akari*	*Rickettsia rickettsii*	*Coxiella burnetii*	Psittacosis virus
0	0	+++	+++	+++	+++	+++
50	0	–	–	–	+++	+++
50	0.05	–	–	–	+++	+++
50	0.5	++	++(+++)	++(+++)	+++	+++
50	5	+++	+++	+++	+++	+++
100	0	–	–	–	+++	+++
100	0.1	–	–	–	+++	+++
100	1.0	++(+++)	++(+++)	++(+++)	+++	+++
100	10	+++	+++	+++	+++	+++
200	0	–	–	–	++·+++	+++

Degree of growth: –, none; + minimal; ++, moderate; +++, maximal.

In previous studies (*3*) it was shown that the growth of typhus rickettsiae is inhibited by PABA in deep columns of Maitland medium. The results presented in Table 1 demonstrate that the growth of three species of rickettsiae (*R. typhi, R. rickettsii,* and *R. akari*) is inhibited by PABA (0.5–1 mg/ml) in agar-slant tissue culture and that this inhibition can be reversed by POB in 1/100 the concentration of PABA. It may be noted that inhibition of *E. coli* by PABA is also reversed by POB in 1/100 the concentration of PABA (*5*). *C. burnetii,* which was reported to be least affected by PABA in the chick embryo (*9*), also is not readily susceptible to the action of PABA (1–2 mg/ml) on agar tissue culture. On a morphological, tinctorial, and cultural basis, the organism is a typical rickettsia. It requires living tissue to propagate, it stains similar to and looks like other rickettsiae. It distinctly differs from three other rickettsial organisms, however, in its susceptibility to the growth-inhibitory action of PABA, as well as in certain other biological characteristics (*10*).

Since the preservation of cell morphology of cultured tissue is, microscopically, quite satisfactory, and since both the virus of psittacosis and *C. burnettii* grow readily on agar media containing PABA (1–2 mg/ml), it is clear that the inhibitory action of PABA on the growth of the three species of rickettsiae is selective.

The agar-slant tissue culture technique has advantages and affords a procedure for studying the growth requirements of rickettsiae and viruses and for testing materials which may influence their growth.

Details of these and further studies will be published elsewhere.

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On the Presence of the Triphosphothiamine (TPT) in the Liver

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The presence in the liver of thiamine and of its diphosphoric ester (DPT) is too well known to require mention; we have obtained evidence for the existence of a triphosphoric ester of thiamine (TPT) in the liver of the albino rat by a chromatographic procedure. This is an adaptation of the methods suggested by Spadoni and Tecce (*1*) and by Viscontini and Karrer (*2*) for the separation of thiamine and of its phosphoric esters in pure solutions.

About 3–4 g of liver are homogenized in 3 vol of 0.2 *N* HCl with the Potter-Elvehjem homogenizer. The homogenate is heated in a boiling water bath for 5 min; while still warm the pH of the homogenate is

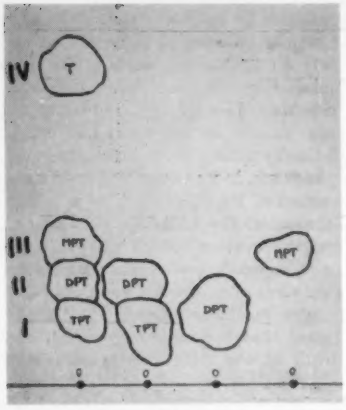

FIG. 1. Chromatogram obtained from solutions of 1 mM thiamine, monophosphothiamine, diphosphothiamine, and triphosphothiamine. Each spot corresponds approx to 10 μg of each compound.

brought to 6.2 by addition of 10% NaOH. After centrifugation at 3000 rpm for 5 min, the clear supernatant is brought to pH 4.5 by addition of 10% trichloracetic acid. Two g of fuller's earth is then added, and the mixture is stirred vigorously for 10 min. After centrifugation the supernatant is discarded and the fuller's earth is washed with a mixture of ethanol-ethyl ether (1:1) in order to eliminate the fatty substances. Thiamine and its esters are then eluted by stirring the fuller's earth with 3 ml of a mixture of pyridine-water-acetic acid (4:1:0.1) for 10 min. The elution fluid is first separated by centrifugation and then concentrated at room temperature *in vacuo* to approx 0.2 ml. One tenth of the concentrated fluid is used for ascending chromatography on strips of Whatman No. 1 filter paper (3.5 × 45 cm) and a pyridine-water-isobutyl alcohol mixture (2:5:3) as solvent. The solvent is allowed to rise to a height of 30 cm. The paper is then dried in a current of hot air

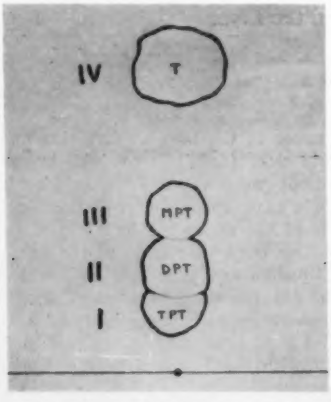

FIG. 2. Chromatogram obtained from 3 g rat liver.

and sprayed with a mixture of 55% ethanol, 10% NaOH, 2.5% $K_3Fe(CN)_6$ (5:5:0.1). Thiamine and its esters are in this way transformed into the corresponding thiochromes and will appear as fluorescent blue spots in ultraviolet light.

A typical chromatogram obtained from an aqueous solution of thiamine and its mono-, di-, triphosphoric esters is reproduced in Fig. 1. A chromatogram obtained from the liver of rat is presented in Fig. 2.

Figs. 1 and 2 reproduce only the areas of fluorescence. For approximate comparative evaluation of the single spots the intensity of fluorescence of the spots should also be taken into account. Spot No. 4 (thiamine) is generally less intense than other spots.

It will be seen that the four spots obtained in Fig. 2 correspond to those of Fig. 1. By addition of T, MPT, DPT, and TPT to the liver extracts the same four spots were obtained.

TABLE 1*

	Total P (μg)	Hydrolyzable P (μg)	Cocarboxylase activity (CO_2 mm³)	Hydrolyzable P × 100 / Cocarboxylase activity ratio	Solubility in isobutyl alcohol
I Spot (TPT)	1.01	0.71	36	1.95	–
II Spot (DPT)	1.15	0.63	56	1.12	–
III Spot (MPT)	0.31	0	0	—	–
IV Spot (T)	0	0	0	—	+

* All the values are referred to 1 g of rat liver. (TPT = triphosphothiamine; DPT = diphosphothiamine; MPT = monophosphothiamine; T = thiamine.)

In order to identify the four compounds we have sought further evidence. Two chromatograms were run in parallel: one (A) was used to localize the spots; the other (B) was then placed upon A, and disks were cut from the paper in the position corresponding to the spots. The disks were eluted with water and the elution fluid was used for the following determinations:

1) The total phosphorus (*3*).

2) The hydrolyzable phosphorus in 2 *N* HCl at 100° for 10 min (by this treatment, according to Viscontini *et al.* (*4*) all the polyphosphoric esters of thiamine are hydrolized to MPT).

3) The cocarboxylase activity (*5*).

4) The ratio "hydrolyzable phosphorus/cocarboxylase activity." (Since TPT and DPT exert practically an identical enzymatic action, the ratio hydrolyzable phosphorus/cocarboxylase activity allows us to determine the number of hydrolyzable phosphoric radicals present in the molecules of the examined compound.)

5) The microbiological activity (*6*).

6) The solubility in isobutyl alcohol (*7*).

The evidence (Table 1) is as follows:

1) Spot I consists mainly of TPT, because the compound has a cocarboxylase activity and the hydrolyzable phosphorus/cocarboxylase activity ratio is practically

equal to 2. This means that for each enzymatically active molecule two labile phosphate radicals are present.

2) Spot II consists mainly of DPT, because the compound exerts a cocarboxylase activity and the hydrolyzable phosphorus/cocarboxylase activity ratio is practically equal to 1. This means that for each enzymatically active molecule one labile phosphate radical is present.

3) The compound present in Spot III can be identified with the MPT because, although inactive as cocarboxylase, it has a microbiological activity; it contains bound phosphate which is not split by 10 min hydrolysis; its thiochrome derivative is not soluble in isobutyl alcohol.

4) The compound present in Spot IV can be identified with thiamine because it does not contain phosphorus, is microbiologically active, and is readily soluble in isobutyl alcohol.

Researches on the presence of phosphoric polyesters of thiamine in other organs and on the enzymatic breakdown of these compounds will be published later.

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Manuscript received June 10, 1952.

Comments and Communications

Plankton Terminology

The term "ultraplankton" has been used recently (*1–3*) to describe the smallest known elements of the marine plankton—e.g., flagellates and green and blue-green algae, which are now generally recognized as being of primary importance as food for the majority of marine larvae (*1, 4, 5*). The use of this term has arisen from the need to differentiate the smaller members of the nannoplankton (or nanoplankton) from the great mass of larger flagellates, nonmotile algae, and peridinians that are too large to serve as food for the early larvae of worms, mollusks, crustaceans, etc.

To the writer the word "ultraplankton" is unacceptable, and it appears desirable to suggest an alternative before it gains general currency. "Ultraplankton" is of bastard Latin and Greek origin and, further, does not bear the meaning ascribed to it by its users. The prefix *ultra* is commonly translated as "beyond," as in ultramarine or ultraviolet, but the combination "ultraplankton" is practically meaningless. Nor is the term "μflagellates," as used by Scottish workers (*6, 7*), admissible, except colloquially, since there are many nonmotile algae present in company with flagellate forms.

It is suggested that the term "hekistoplankton" should be adopted (ἥκιστος = "least") and should be defined as including all those elements in the plankton 10 μ or less in diameter of cell body. The limit 10 μ is suggested since the majority of larger forms cannot be ingested by marine larvae. It is in relation to their value as food for such larvae that these small elements in the plankton are principally studied; they apparently form the basis of the food chain in most marine planktonic communities.

In preparing this note I have had the benefit of advice on the choice of words of my colleague, M. N. Mistakidis, who has also drawn my attention to the frequent use of the prefix *macro* when *megalo* would be more appropriate. I understand that in modern usage "μακρος" is used to describe objects that are long rather than generally bulky, for which "μεγαλος" is more appropriate.

H. A. Cole

Fisheries Experiment Station, Conway, North Wales

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The Green Peach Aphid on Tobacco in the Dominican Republic[1]

The green peach aphid, *Myzus persicae* (Sulzer), first appeared in the United States in economically destructive numbers in 1946, in Gadsden Co., Fla. (*1, 2*). Ever since, its progression across the tobacco fields of the U. S. has brought forth various explanations for the phenomenon of its distribution. One explanation frequently advanced is that the development of infestations bears some correlation to the introduction of new synthetic insecticides, especially DDT, in and near the established tobacco-growing areas; it claims, in effect, that these insecticides destroy the natural predators of the aphids and that before these

[1] A contribution from a technical agricultural project in the Dominican Republic, operated jointly by the government of the republic and by the Office of Foreign Agricultural Relations, USDA. U. S. participation in this work is carried out as part of the Point IV program in the Dominican Republic, administered by the Technical Cooperation Administration, U. S. Department of State.

insecticides were used a nearly complete biological control existed. In the Dominican Republic, such claims for the insecticides, however, are not supported by the circumstances, which are, for this reason, presented here.

The green peach aphid was first discovered in the Dominican Republic, in January 1951, by Chupani and Ginberg, two members of the Dominican Department of Agriculture. They found it throughout the Cibao Valley, with the heaviest infestations west of Santiago. Samples of these aphids collected in March 1952, were identified as *Myzus persicae* (Sulzer) by Louise M. Russell, of the U. S. Bureau of Entomology and Plant Quarantine.

Before January 1951 no report is known to have been made of aphids occurring on tobacco in the Dominican Republic—a remarkable record, considering that tobacco has been an important agricultural crop in that country since pre-Columbian days. Harry and Howard Allard, who made an intensive study of pests on Dominican tobacco in 1947 (*3*), do not include Aphididae in their paper. It is doubtful that these observers would have failed to note aphids on tobacco if they had been present.

In February 1952, the distribution of the aphids was general in the tobacco-growing regions of the republic, extending east and west through the Cibao Valley and south as far as Bonao (Monseñor Nouel.) The intensity of the infestations varied from light to very severe, the latter category implying the presence of honeydew and cast skins on the underside of leaves, which were thus rendered commercially worthless.

Lead arsenate has been the only insecticide used in these agricultural areas, and then only in a very limited way for certain chewing insects. We are not aware that any of the new synthetics had been used on any crops in the tobacco-producing regions before the aphids were discovered. The status of the natural predators had not been disturbed by any chemical poisons. Nevertheless, the predators have not responded to the opportunities afforded them. For example, the populations of several of the lady beetles in fields heavily infested with aphids for the second year have been rather scant.

Support is found for the interesting theory of George N. Wolcott (*4*), entomologist of the Insular Experiment Station at Río Piedras, Puerto Rico, that the aphids have been windborne to Hispaniola and Puerto Rico from Cuba, where they have become an important pest since they first were found there, in 1948.[2] The green peach aphid appeared on these two islands to the east of Cuba at the same time, being observed on tobacco in January 1951 both in the Dominican Republic and in Puerto Rico. It quickly established itself as a pest of considerable economic importance in both islands.

So far, this aphid has been rather selective as to its host plant. In many Dominican tobacco fields, tomatoes and eggplants are found growing adjacent to tobacco that is heavily infested with aphids. Such plants either have been planted by the farmer for his own use or are of volunteer growth from a previous crop. We have yet to observe aphids on these other solanaceous plants, even where the adjoining tobacco plants may be very heavily infested. Does this indicate, as Wolcott has suggested in correspondence this year, that the aphids found on the Dominican tobacco are morphologically indistinguishable but, on the basis of host selection, physiologically distinguishable from those previously present in the West Indies?

ERNEST G. BEINHART[3]

[2] *The editors fail to see how Wolcott's theory of windborne migration is supported in a region where the prevailing trade winds blow consistently from Puerto Rico to the Dominican Republic to Cuba, and where the rare reversals of wind direction are associated with hurricanes, the radii of which are much too small to bridge the water passages between these islands.*

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[3] Tobacco specialist, Office of Foreign Agricultural Relations, on assignment to the Dominican Republic.

Shipping Small Animals

I AM glad to report that the difficulties with transportation of live materials for research, cited by Wm. Hegener in your July 4 issue (SCIENCE, **116**, 20 [1952]), are well on the way toward solution, at least with respect to air express.

Through the intervention of Barry King, research executive of the CAA Medical Division, an excellent memorandum on the subject has been sent to members of the Air Express Traffic Committee by its executive secretary, Emery F. Johnson, of Air Cargo, Inc. We know of at least one positive response to this memorandum—National Airlines has gone on record as accepting small laboratory animals on all flights, provided they are: (1) consigned to a recognized research organization and all parts marked "Live Animals for Research Purposes;" (2) inoffensive to passengers and crew at National's discretion; (3) packaged in such a manner as to be leakproof and require no care in transit; and (4) of a size readily handled on board all types of aircraft.

National has stated that it is wholly in sympathy with the problems being experienced in shipping animals for research purposes, and that it was amending its tariffs because of the pressing humanitarian need for this research.

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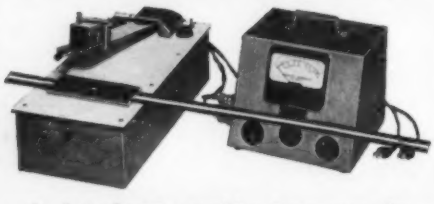

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Jan. 26–29. American Society of Heating and Ventilating Engineers (Annual). Conrad Hilton Hotel, Chicago.

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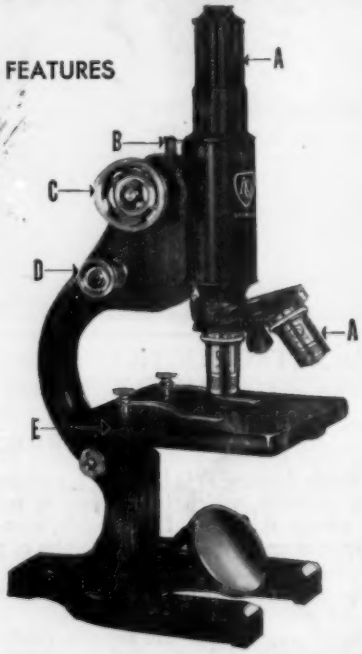

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